**National Park Service**
**U.S. Department of the Interior**

**Natural Resource Program Center**

# SOP for Collecting Sea Otter Forage Data ─ Version 3.2

## *Southwest Alaska Inventory and Monitoring Network*

Natural Resource Report NPS/SWAN/NRR—2011/394

**ON THE COVER**
Kim Kloecker (USGS) and Jim Bodkin (USGS) collecting sea otter foraging data, Kenai Fjords National Park.
Photograph by: Dr. Allan Fukuyama, USGS Contractor, Kenai Fjords National Park.

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Natural Resource Report NPS/SWAN/NRR—2011/394

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# Revision History Log

All edits and amendments made to this document since its inception should be recorded in the table below. Users of this protocol should promptly notify the project leader of the marine nearshore monitoring program of recommended edits or changes. The project leader will review and incorporate suggested changes as necessary, record these changes in the revision history log, and modify the date and version number on the title page of this document to reflect these changes.

### Revision History Log:

| Previous Version # | Revision Date | Author | Changes Made | Reason for Change | New Version # |
|---|---|---|---|---|---|
| Version 1 | 08/12/2010 | Coletti | Formatting; updating to reflect SWAN | To meet NRR standards, remove NGEM references | 3.1 |
| Version 3.1 | 01/07/2011 | Bodkin | edits | clarity | 3.2 |
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| | | | | | |
| Add rows as needed for each change or set of changes associated with each version. | | | | | |

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# 1 Background and Objectives

## 1.1 Introduction

The purpose of this SOP is to quantify foraging success as well as the types, number, and relative sizes of prey retrieved and consumed by sea otters. Taken together these data provide estimates of consumption rate (e.g. kcal/hr) that may be an index of sea otter population status relative to over-all food availability while more detailed analyses may provide indices of species specific prey population abundances and sizes. Sea otters forage almost exclusively on sessile or slow moving benthic invertebrates and bring all prey to the sea surface prior to consumption. Because their foraging is limited to relatively shallow waters (Bodkin et al. 2004, Appendix B), shore based observers equipped with high power and resolution telescopes can often accurately identify the type, number, and sizes of prey consumed. Observations of sea otter foraging success and intensity will be measured using focal animal foraging observations (Altmann, 1974) adapted for sea otter work in past studies (Calkins 1978, Estes et al. 1986, Doroff and Bodkin 1994). Observations will consist of shore based, near shore observations at selected sites within the KATM and KEFJ study areas using high resolution telescopes.

Observations of foraging sea otters will provide information on food habits, foraging success, (mean proportion of feeding dives that are successful) and efficiency (mean kcal/dive) based on prey numbers, types and sizes obtained by feeding animals. Because sea otter populations are often prey limited, data on foraging behavior will be useful in evaluating reasons for differences in sea otter densities or trends among regions or years (Estes et al. 1982, Gelatt et al. 2002, Dean et al. 2002, Bodkin et al. 2002).

Due to high spatial variability in marine invertebrate populations (e.g. extreme patchiness) and difficulty in sampling underwater prey populations, foraging sea otters provide an alternative method to direct sampling of subtidal invertebrates. Following a successful foraging dive, sea otters return to the surface to consume their prey. This provides the opportunity to identify, enumerate, and determine the size of the benthic organisms they consume. Therefore sea otter foraging foraging observations will provide data on species composition and sizes of subtidal invertebrate prey populations that are difficult to obtain directly. Observations collected over time may allow inference to changes in the species composition and sizes of nearshore benthic invertebrate communities.

Data on sea otter food habits, foraging efficiency, and prey sizes should prove useful when examining differences (if any) obtained through direct measures of densities, and size-class distributions of the invertebrates obtained through the intertidal invertebrate and algal data collection (see the Sampling of Intertidal Invertebrates and Algae on Sheltered Rocky Shores SOP). Data collected on species composition and sizes of invertebrates recovered by sea otters will allow evaluation of changes in intertidal and subtidal benthic communities in different regions and over time. Sea otter foraging data, including diet composition, foraging efficiency, and prey sizes will be useful in evaluating the role of food limitation as a factor as sea otter population sizes change over time.

### 1.2 Rationale for collecting sea otter foraging data

The sea otter (*Enhydra lutris*) may be the most common and conspicuous mammal in nearshore marine habitats in the north Pacific. It also may be the best understood marine mammal, in ecological terms, because of its well described role as a “keystone” predator in nearshore marine benthic ecosystems (Estes and Palmisano 1974, Estes and Duggins 1995). The sea otter is limited in distribution to shallow coastal waters by a diet that consists largely of benthic marine invertebrates (crabs, clams, urchins, snails) and a foraging depth range from the intertidal to about 100 m (Bodkin et al. 2004a). The species aggregates to rest, typically in nearshore areas, has relatively small home ranges (tens of kilometers of coastline), usually forages alone, has dive times that average < 2 minutes, and brings their prey to the surface for consumption. These characteristics support direct visual observation and provide for accurate and precise estimates of sea otter foraging behavior.

### 1.3 Measurable Objectives

Collecting sea otter foraging data to quantify foraging success as well as the types, number, and relative sizes of prey retrieved and consumed by sea otters.

- Estimate prey species composition, prey number, and prey sizes.
- Estimate forage dive attributes (success, dive times, surface times).
- Estimate energy recovery rates of foraging sea otters.
- Document change in sea otter diet over time.

# 2 Sampling Design

## 2.1 Rationale for Selecting this Sampling Design over Others

A stratified random sampling design will be used to obtain and evaluate foraging data and to examine differences in foraging and prey species recovered between regions, years, and the interaction between regions and years. Metrics to be analyzed include the frequency distribution of prey sizes, the mean size of prey recovered, and the mean kcal of prey obtained per hour of foraging. The latter is derived from prey type, prey size, number of prey, and reported caloric values and weight/length relationships of each prey along with forage dive success rates and mean dive and prey handling times (see Kvitek et al. 1992, Doroff and DeGange 1994, Dean et al. 2002). The sampling unit for each is a foraging bout (observations of repeated dives for a single sea otter on a given day while it remains in view and continues to forage (Calkins 1978). Ten bouts will be observed within a 10 km radius of five randomly selected sites within each intensive sampling block each year (see figure 2), resulting in a minimum of 50 bouts per intensive block per region. These sites are those where intensive sampling for intertidal invertebrates and algae is to be conducted (see intertidal invertebrate and algal SOP for details of intertidal site selection). Observations are to be made at each site annually, between April and July.

## 2.2 Choosing Sampling Units

See SWAN Nearshore Protocol (Dean and Bodkin 2011)

## 2.3 Recommended Frequency and Timing of Sampling

See SWAN Nearshore Protocol (Dean and Bodkin 2011)

## 2.4 Level of Change that can be Detected

This sampling design allows estimation of sea otter diet composition, species specific prey sizes and numbers, and energy recovery rates within the intensive block within each region. Based on prior sea otter forage data collected in Prince William Sound, power analyses indicate sample sizes of 40 bouts were adequate to detect a change in caloric recovery rates of 10%, with 80% power. This equates to a change of approximately ≤1 hour/day in the mean time required to meet daily energetic requirements.

# 3 Field Season

## 3.1 Observation conditions

Observations of foraging sea otters are facilitated by viewing conditions that include proximity, an elevated viewing position, and back lighting (or an overcast sky). Observation distances should generally not exceed 1 km, and selection of individuals should be directed toward individuals that afford preferred viewing conditions. Generally increasing wind velocities result in reduced viewing conditions, although selection of a viewing area with shelter from wind can reduce the negative effects of winds. Observations should not be made under conditions that compromise the ability of the observer to obtain accurate estimates of prey species, number or size.

### 3.2 General methods

Food habits, foraging success and efficiency will be derived from shore based observations of randomly selected foraging otters.  Shore based observations limit data collection to sea otters feeding within approximately 1 km of shore. High power telescopes (Questar Corp., Hew Hope, PA.) and 10X binoculars will be used to observe and record prey type, number, and size during foraging bouts of focal animals. A bout consists of o repeated observations of dives for a focal animal while it remains in view and continues to forage (Calkins 1978). Assuming each foraging bout records the feeding activity of a unique individual, bouts will be considered independent while dives within bouts will not. Thus the length of any one foraging bout will be limited to about 20 dives, or one hour, after which a new focal animal will be chosen.

Sea otters in the study areas are generally not individually identifiable. In addition, some foraging areas may be used more than others by individuals and by otters living in the area in general. Therefore individual sea otters may be observed more than once leading to potential bias toward individuals sampled more than once. To minimize this potential, observers should use characteristics such as sex, sizes, coloration, and reproductive status to identify individuals. Four persons working in 2 teams will spend 5 days sampling in intensively sampled blocks (see Nearshore Monitoring Protocol, Dean and Bodkin 2011) within each study region each year. One day of observation is to be devoted to each of the five sites for intensive sampling of intertidal invertebrates and algae.

### 3.3 Field Season Preparation

In preparation of data collection the following equipment and supplies should be compiled and tested for operation:

**Table 1.** Equipment required for collecting sea otter foraging data.

| Check | Equipment | Quantity | Description |
|---|---|---|---|
| | Telescope | One per observer | 50-80 X Field Model Questar telescope |
| | Tripod | One per observer | Suitable for the Questar telescope and capable of use in uneven terrain and winds up to 20 mph. |
| | Stopwatches and spare batteries | Two per observer | For recording dive and surface intervals. Stopwatch must be capable of recording and displaying consecutive intervals without resetting the watch. |
| | Binoculars | One per observer | High resolution 10X. |
| | GPS | One per observer | 10 m accuracy GIS with compass capability. Set display to WGS84 datum. Set position to be based on estimated distance and compass bearing. Compass should be set to magnetic degrees. |
| | Data Sheets | 5 or more double sided per observer per day. | Data sheets should be printed on plastic or other waterproof paper, double sided. |

| Check | Equipment | Quantity | Description |
|---|---|---|---|
| | Data Code Sheet | One per observer | Copy of data codes and prey codes printed on plastic paper and bound to the clipboard |
| | Data Entry SOP | | Data entry standard operating procedures and electronic data file for data entry |
| | Computer | | For data entry and management |
| | Miscellaneous supplies | Each observer | • Clipboard<br>• 2 pencils<br>• Optic drying and cleaning supplies<br>• Radio or communication device |
| | Personal outdoor clothing | Each observer | Field personnel must be dressed appropriately for extended periods outdoors in wet and windy weather. Rain pants, jacket, and boots are recommended. Spare dry socks, gloves and a hat should be carried. |
| | Safety Equipment | Each observer | Minimum requirements<br>• Radio with spare batteries<br>• Signaling device (mirror, flares)<br>• Flashlight or headlamp<br>• Fire starting kit |
| | Training | One of each pair of observers | • Wilderness first-aid<br>• Bear safety<br>• Boat safety |

## 3.4 Sequence of Events

### *3.4.1 Site and foraging animal selection*

Sea otter foraging observations will be made within each Park (KATM and KEFJ). Observations of foraging will be made from within a 10 km radius of each of the 5 sites where intensive sampling for intertidal invertebrates and algae is conducted. This radius my be changed based on the abundance and distribution of sea otters relative to each of the five intensive protected rocky intertidal sites.

The goal will be to obtain foraging data on at least 50 sea otters from KATM and KEFJ each year, resulting in 50 bouts per park per visit. The shorelines around each site will be surveyed by skiff to find foraging sea otters and to locate and access a suitable location for making observations. In general, the location from which observations are to be made should be within 500 m of foraging sea otters and from a vantage point offering maximum elevation above sea level.

If more than one foraging animal is available for observation at any particular observation site then the individual affording the preferred viewing conditions will be selected. If viewing conditions are equitable among individuals the first one will be randomly selected (coin toss between pairs), and after completion of the bout the process repeated with the remaining animals. If recognizable (tagged) individuals are available for observation their identification will be recorded (color and location of tags on hind flippers) and observations will be limited to no more than 1 bout/individual for each sampling period. Data will not be collected on dependent pups (i.e. pups that are in close proximity to female otters).

### *3.4.2 Foraging Observations*

For each bout the otters estimated age (juvenile or adult, based on total length, extent of grizzle on head, and behavior) sex (presence/absence of penile bulge, pup or mammary glands, or undetermined), and reproductive status (independent or with pup) will be recorded. Estimated distance from shore will be recorded and foraging location of the focal sea otter will be recorded by GPS position. The foraging depth and habitat type will be later estimated by overlaying coordinates onto GIS maps of bathymetry or bottom type (if available).

For each feeding dive, observers will record dive times (time underwater searching for prey, including travel time) and surface intervals (time on the surface between dives) along with dive success (prey captured or not). In addition, prey identification (lowest possible taxa), prey number, and prey size (see Appendix A) will be recorded. Prey size will be estimated using the otters fore paw width as a reference with an average width of about 52 mm. Adjustments may be required when observing individual sea otters that are either smaller or larger than the "average" adult. When more than one prey item is retrieved by a focal animal and all prey are not of the same type or size, then the number of prey of each size and/or type will be recorded separately but with the same dive number on the data sheet. The mean success rate, mean prey number, mean prey size, and most common prey type will be determined for each bout.

The goal for forage observations will be to collect data from at least 400 foraging dives over at least 50 foraging bouts of $\geq$10 bouts per site, collected over the range of daylight hours and tide levels. A bout will contain a minimum of 1 foraging dive. A maximum of about 20 dives per bout will be recorded. The maximum time a single sea otter is observed is not to exceed one hour. Individual bouts will be identified by region, park and site number for the associated intertidal invertebrate and algal sampling location. Geographic coordinates for the location of the foraging animal from which observations were made and date, time, and year, and sequential bout number within each site will be recorded.

## 3.5 Recording Data

Observations within each block will occur in conjunction with the intertidal sampling of invertebrates and algae at each of the five intensive sampling locations. Two teams of observers will locate foraging sea otters within the 10 km radius from the intertidal site and begin data collection. Although some animals may be foraging during all daylight hours, data collection efforts may be focused during the morning and afternoon periods if sea otter foraging activity is concentrated during these times.  Because foraging activity is generally a solitary activity, it may be necessary for observers to relocate during the data collection period to different observation points.  Relocation may take place either via skiff or by walking along the shoreline. Following each forage bout the team of observers should review the data collected for that bout to ensure completeness of data collection. At the end of each day the team of observers should review all bout data for completeness, renumber each bout with a unique bout number based on the intensive site segment and region and date, and should enter the data into the electronic data base (see 4.3 below). Because sea otter foraging habitat remains fairly consistent over time, and the program objective is to detect change over time, efforts should be made to identify foraging areas prior to initial data collection and efforts in future years should be directed toward those same areas.

### 3.6 Post-collection Processing of Data

After each field day, the following tasks are to be completed:

- Field personnel are to review data sheets and edit as necessary to improve legibility and resolve any discrepancies.
- Make identifications (if possible) of any taxa for which field identifications were in question and revise taxa names and codes on data sheets accordingly.
- Enter data from data sheets into computer files. Verify the data entry.
- Make a backup copy (cd or other removable media) of all data collected.
- Check and replace or charge batteries in electronic equipment (including radios) as needed.
- Provide a summary of activities and observations for the day including any problems, suggestions for modifications in procedures, and unusual occurrences or observations.
- Prepare field sheets and equipment for the following day's use.

After each field trip or cruise, the following are to be completed:

-Produce a summary of the cruise based on summaries of daily activities and observations

### 3.7 End-of-season Procedures

At the end of each field season all equipment should be cleaned and serviced, and batteries removed for storage. Optics, tripods, and other equipment should be assessed for repair or replacement needs.

After each field season, the following are to be done:

- Clean and check all mechanical, optical, and electronic equipment and field gear for needed repair and store appropriately.
- Make repairs or obtain replacements for damaged or lost equipment or supplies.
- Produce a field season summary report based on daily and cruise reports.

# 4 Data Handling, Analysis and Reporting

## 4.1 Metadata Procedures

The sea otter foraging data collection procedure is designed to meet two objectives. One is to estimate the species composition and mean sizes of invertebrate prey recovered by foraging sea otters. These data will be used to evaluate change over time in these attributes within the SWAN regions. The second objective is to estimate the foraging efficiency of sea otters in each of those same regions. Foraging efficiency will be calculated based on dive and surface times, the size and number of taxa specific prey and their caloric content, and the estimated daily caloric requirements of sea otters. These data will be used to evaluate the role of food limitation in changes in trends of sea otter populations over time (see sea otter aerial survey SOP).

The data collection form, data dictionary and prey codes are provided in Appendix A.

## 4.2 Overview of Database Design

This database is currently under development.

## 4.3 Data Entry, Verification and Editing

Data currently is entered from field datasheets into Microsoft Excel. Data is entered as soon as possible upon returning from the field. Raw data files are backed-up and the project manager verifies that data within the .Excel spreadsheets matches the hardcopy recorded by the observer. The project manager edits data to correct discrepancies.

## 4.4 Routine Data Summaries and Statistical Analyses

The overall analytical approach is described in the SWAN Nearshore Marine Protocol (Dean and Bodkin 2011) that relies on data collected from most sampling protocols. In preparation of providing data derived from this data collection, annual summaries should be completed.

**Invertebrate prey species composition.** Within each park prey species composition will be summarized by the proportion of each prey taxa consumed for each sampling period (year). Proportions will be arcsine transformed to normalize data, and data tested for equality of variances prior to analysis. Chi-square analysis will be used to test for differences in proportions over time within regions. Invertebrate prey number recovered per dive will be summarized by the mean and standard error by prey taxa within region. Analysis of variance (anova) will be used to test for differences in mean number of prey by taxa over time, within region. Invertebrate prey sizes will be summarized by the mean and standard error by prey taxa within region. Analysis of variance (anova) will be used to test for differences in mean sizes of prey over time, within region.

For each region and year, the proportion of prey types consumed, mean number, and mean size, and kcal of energy recovered per hour will be calculated and plotted. Calculation of energy recovered per unit time will follow the procedures described in detail in Dean et al. (2002, Appendix C) and excerpted as follows, with the following exception; prey sizes will be based on those estimated from forage observations, with the midpoint of each size class used to estimate caloric content, rather than shell remains:

*“**Rate of consumption of food by sea otters.** The average prey consumption rate by sea otters in each study area was calculated based on measurements of: 1) the time of an average dive, 2) the time interval between dives, 3) the proportion of dives that were successful in obtaining food, 4) the type, number, and size of prey obtained on each successful dive, and 5) the average energy content of each prey. One through four above were based on direct foraging observations made from sites along the shoreline using a 50 to 80 power spotting scope while five was based on estimates from sea otter cracked shells from sea otter foraging sites (see below). Observations were made during daylight hours in June through August 1996 through 1998. A total of 117 foraging observation sessions were conducted at Knight Island and 113 were conducted at Montague Island. An average of eight dives per session was observed in each area. Energy conversions were made based on expressions given in Table 3, or from values given in Cummins & Wuycheck (1971) or Wacasey & Atkinson (1987).*

*Observers could distinguish prey type (clam, mussel, crab, sea urchin, etc.) and the size class (< 4, 4 to 8, or > 8 cm in length) of each prey, but could not accurately estimate size or, in the case of clams, species. Therefore, we estimated the species composition of clam prey and average size of each species of clam based on collections of sea otter-cracked shells from sea otter foraging sites. This method is based on the unique way in which sea otters feed and the ability of divers to distinguish otter-cracked shells from others (Kvitek et al. 1988, 1992, Fukuyama 2000). A total of 33 and 30 foraging sites were sampled at Knight and Montague Islands respectively in summer 1996 and 1997. An average of 11 to 20 otter-cracked clam shells was collected and measured at each site. Only newly deposited shells (based on color and degree of epifaunal growth) were included.*

*We tested the hypothesis of no difference in consumption rate between Knight and Montague Islands using a Monte-Carlo re-sampling method (Manly 1991). We estimated a statistical distribution for each of the observable attributes used in the calculation of consumption rates (dive times, number and size of prey, etc.). Data from both study sites were combined to represent a null distribution of no difference between populations at Knight and Montague Islands. A sample size of 113 (Knight) and 117 (Montague) was randomly selected from the distribution of each attribute, the averages of these were computed, and a difference calculated. This process was repeated 1,000 times to create a Monte Carlo simulation of the null distribution of differences. The observed difference in consumption rates was estimated using the site-specific mean values for each attribute to derive one consumption rate for each area. The statistical significance of the difference in consumption rate was estimated by the proportion of the null distribution of differences that was greater than the observed difference. This can essentially be interpreted in the same manner as the probability associated with a t-statistic testing the hypothesis of no difference between means. We also calculated 95% Monte-Carlo confidence intervals for consumption rates. The Monte Carlo procedure included drawing a random sample of the site-specific attributes of sample size 113 and 117, for Knight and Montague respectively. We again used the mean values to estimate the new consumption rate and repeated the process 1000 times for each area. Confidence limits were estimated by the 2.5% and 97.5% points in the Monte Carlo distribution of consumption rates.*

*The consumption rates for sea otters at Knight and Montague Islands in 1996-1998 were contrasted with comparable data from other PWS sites (Garshelis et al. 1986) and from Kodiak Island collected prior to the spill. Means and 95% confidence intervals were estimated for consumption rates at Kodiak largely using published data from these sites as inputs. Calculations were made in the same manner described above for Knight and Montague. Foraging data for Kodiak Island (Doroff & DeGange 1994) were collected in a manner similar to those described for PWS. Size distributions of clams at Kodiak Island were based on shell litter collections (Kvitek et al. 1992)".*

Multivariate analysis of variance (manova) will be used to make between area comparisons of mean kcal/dive, and proportion successful dives, along with mean dive time, and prey size for similar prey items. If sample sizes are sufficient, the analysis will be run using age and sex class, depth and location (segments within parks).

Trends in variables collected (proportion of prey recovered, mean number and sizes, and mean success rate and calories recovered per hour) will be plotted over time. As time series of data increases, multiple regression procedures will be used to evaluate relations between species composition, prey number and sizes, and calorie recovery rates.

Annual reporting will include summaries and graphs, as outlined above, for species composition mean number and sizes of taxa specific prey, dive success rates, and calorie recovery rates, by region. Examples of summary tables of data follow (Tables 1-5 adapted from Bodkin et al. 2004b):

**Table 2**. Number of foraging bouts, total dives and mean number of dives per bout for sea otters at Izembek Lagoon, Clam Lagoon and outer coast areas of Adak, AK, 2002. Maximum and minimum number of dives per bout were 35 and 5 dives, respectively.

| Area | No. foraging sessions | Total dives | Mean # dives |
|---|---|---|---|
| Izembek Lagoon | 46 | 819 | 18 |
| Clam Lagoon | 46 | 939 | 20 |
| Adak's outer coast | 45 | 468 | 10 |
| **TOTAL** | **137** | **2226** | **16** |

**Table 3.** Means (SD) for foraging data from sea otters at Izembek Lagoon, Clam Lagoon and the outer coast of Adak Island, 2002. A total of 46, 46 and 45 bouts were observed at the respective locations with an average of 16 dives observed per foraging session.

| Variable | Units | Izembek Lagoon | Clam Lagoon, Adak | Outer Coast, Adak |
|---|---|---|---|---|
| Success rate | % of successful dives | 84.8 | 89.9 | 90.6 |
| Time/dive (Dive + surface time) | Seconds | | | |
| Successful | | 69 (20) | 70 (23) | 126 (40 |
| Unsuccessful | | 56 (21) | 57 (34) | 68 (47) |
| Prey composition | % of successful dives | | | |
| Bivalves | | 20 | 73 | 57 |
| Crabs[a] | | 79 | 3 | 13 |
| Prey 3[b] | | 1 | 20 | 22 |
| Other[c] | | <1 | 5 | 8 |
| # of prey/dive | # of individuals | | | |
| Bivalves | | 2.4 (1.2) | 1.7 (0.9) | 1.3 (0.7) |
| Crabs[a] | | 1.2 (0.4) | 1.0 (0.4) | 1.2 (0.9) |
| Prey 3[b] | | 1.0 (0.0) | 2.3 (1.4) | 2.6 (1.3) |
| Other[c] | | | 1.2 (0.5) | 1.2 (0.4) |
| Midsize of prey | mm | | | |
| Bivalves | | 24 (14) | 43 (22) | 63 (22) |
| Crabs[a] | | 39 (13) | 72 (39) | 73 (23) |
| Prey 3[b] | | 78 (28) | 82 (24) | 36 (13) |
| Other[c] | | | 71 (29) | 101 (67) |

[a] Species of crabs included *Telmessus cheriagonus*, *Cancer* sp., *Lithodes aequispinus, Pugettia gracilis*. Category also includes unidentified crab species.
[b] "Prey 3" refers to a third common prey type taken which varied by location. Prey 3 corresponds to the following items by location: Izembek Lagoon-echiurid worms; Clam Lagoon-annelid worms; Adak's outer coast-*Strongylocentrotus droebachensis*)
[c] "Other" includes the following items by location: Izembek Lagoon- algae/kelp; Clam Lagoon-*Echiuris* sp., *Ammodytes hexapterus*, *Clinocardium* sp., *Musculus discors, Mytilus edulus*, *Leptasterias* sp., unidentified fish sp.; Adak's outer coast- *Ammodytes hexapterus,* flatfish (*Hippoglossus stenolepis, Lepidopsetta bilineata*), *Leptasterias* sp., *Octopus* sp., unidentified fish sp., Porifera, Annelida, algae/kelp.

**Table 4.** Composition of prey species identified in sea otter diets at Izembek Lagoon, Adak AK, from June 18 – July 13, 2002. Prey items were identified to the lowest possible taxonomic level. Unidentified prey not included.

**Izembek Lagoon**

| Prey Type | Possible taxa | N | Percent of total |
|---|---|---|---|
| helmet crab | *Telmessus cheiragonus* | 415 | 78.3 |
| clam | *Macoma* sp., *Mactromeris* sp., *Siliqua* sp. | 94 | 17.7 |
| bivalve, unidentified | Bivalvia | 11 | 2.1 |
| fat innkeeper worm | *Echiuris* sp. | 6 | 1.1 |
| crab | Crustacea | 3 | 0.6 |
| algae/kelp | | 1 | 0.2 |

**Table 5.** Composition of prey species identified in sea otter diets at Clam Lagoon, Adak AK, from July 16 – July 26, 2002. Prey items were identified to the lowest possible taxonomic level. Unidentified prey not included.

**Clam Lagoon**

| Prey Type | Possible taxa | N | Percent of total |
|---|---|---|---|
| Butter clam | *Saxidiomus* sp. | 701 | 53.6 |
| Annelid worm | *Arenicola sp., Nereis*, sp. | 255 | 19.5 |
| Bivalve, unidentified | Bivalvia | 182 | 13.9 |
| Clam (other than butter clam) | *Macoma* sp., *Mya* sp., *Protothaca* sp. | 49 | 3.7 |
| Crab | *Cancer sp*., *Telmessus cheiragonus* | 37 | 2.8 |
| Echiurid worm | *Echiuris* sp. | 27 | 2.1 |
| Sand lance | *Ammodytes hexapterus* | 18 | 1.4 |
| Cockle | *Clinocardium* sp. | 15 | 1.1 |
| Starfish | *Leptasterias* sp. | 13 | 1.0 |
| Mussel | *Musculus discors, Mytilus edulus* | 8 | 0.6 |
| Kelp crab | *Pugettia gracilis* | 2 | > 0.1 |
| Fish | Pisces | 1 | > 0.1 |
| Rock jingle | *Pododesmus macroschisma* | 1 | > 0.1 |

**Table 6.** Composition of prey species identified in sea otter diets along the outer coast of Adak, Is., AK, from July 23 – August 5, 2002. Prey items were identified to the lowest possible taxonomic level. Unidentified prey not included.

**Outer Coast**

| Prey Type | Possible taxa | N | Percent of total |
|---|---|---|---|
| Razor clam | *Siliqua patula* | 107 | 23.9 |
| Sea urchin | *Strongylocentotus polyancanthus* | 100 | 22.3 |
| Clam (other than razor) | *Macoma* sp., *Mya* sp., *Protothaca* sp., *Saxidiomus* sp. | 59 | 13.2 |
| Bivalve, unidentified | Bivalvia | 56 | 12.5 |
| Crab | *Cancer sp., Telmessus cheiragonus* | 56 | 12.5 |
| Rock jingle | *Pododesmus macroschisma* | 35 | 7.8 |
| Sand lance | *Ammodytes hexapterus* | 12 | 2.7 |
| Algae/kelp | | 7 | 1.6 |
| Flatfish | *Hippoglossus stenolepis, Lepidopsetta bilineata* | 6 | 1.3 |
| Starfish | *Leptasterias* sp. | 5 | 1.1 |
| Octopus | *Octopus sp.* | 2 | 0.4 |
| Sponge | Porifera | 1 | 0.2 |
| Fish, unidentified | Pisces | 1 | 0.2 |
| Worm | *Arenicola sp., Nereis sp.* | 1 | 0.2 |

**Table 7.** (adapted from Dean et al. 2002). Estimates of prey consumption and hours spent feeding by adult sea otters (upper and lower 95% CI). Data from Green Island, Nelson Bay and Orca Inlet are from Garshelis et al. (1986); data from Montague and Knight Island are from Dean et al. (2002); data from Amchitka Island are from Gelatt et al. (2002). Feeding data from Kodiak are from Doroff and De Gange (1994) and A.R. DeGange (unpubl.). Shell length and mass to length conversions for Kodiak are from Kvitek et al. (1992) and mass to energy conversions are from Kenyon (1969), Cummins and Wuycheck (1971) and Wacasey and Atkinson (1987).

| Region/Area | Year | Sea otter population status | Prey consumption rate (kJ $hr^{-1}$) | Feeding time required (h $d^{-1}$) |
|---|---|---|---|---|
| PWS [a] / Orca Inlet | 1980-81 | Occupied < 2 yr | 6134 | 5.0[b] |
| Kodiak / Kupreanof Strait | 1986-87 | Occupied < 15 yr | 5100 (4230-6230) | 4.4[b] (3.6-5.3) |
| Kodiak / Afognak Island | 1986-87 | Occupied > 25 yr | 2340 (1482-3337) | 10.0[b] (6.7-15.1) |
| PWS / Knight Island | 1996-98; reduced 1989-1998 | Occupied > 25 yr | 2260 (1980-2570) | 9.9[b] (8.7-11.3) |
| PWS / Nelson Bay | 1980-81 | Occupied 2 to 3 yr | 2187 | 8.8[c] |
| PWS / Montague Island | 1996-98 | Occupied > 25 yr | 1900 (1630-2180) | 11.8[b] (10.3-13.7) |
| PWS / Green Island | 1980-81 | Occupied > 25 yr | 1274 | 11.3[c] (10.7-11.9) |
| NAP [a] / Izembek Lagoon | 2002 | Occupied > 25 yr | 4103 | 6.9 |
| Aleutians / Adak / Clam Lagoon | 2002 | Occupied > 25 yr | 3074 | 8.8 |
| Aleutians / Adak / outer coast | 2002 | Occupied > 25 yr; reduced 1990's - present | 4827 | 5.6 |
| Aleutians / Amchitka 9.9[b]-9.6[c] | 1993 | Occupied > 25 yr; reduced 1990's - present | 2295 | . |

[a] PWS: Prince William Sound, NAP: North Alaska Peninsula.
[b] Estimate based on hours required to obtain energy needed for maintenance (1019 kJ $kg^{-1}d^{-1}$), given the measured prey consumption rate. For Montague and Knight Islands all animals were female and the average sea otter size was 22.5 kg; at Orca Inlet most animals were males and an average size of 30 kg was assumed. At Izembek Lagoon, Clam Lagoon and the outer coast of Adak Island, an average sea otter size of 25.1 kg was assumed. At Amchitka Island feeding time is reported for adult females with an average size of 22.3 kg.
[c] Based on observations of activity from telemetry

**Table 8.** Sex and reproductive status of adult sea otters observed in foraging bouts in Izembek Lagoon, Clam Lagoon and the northern outer coast areas of Adak, 2002.

| Sex/reproductive status | Izembek | Clam Lagoon, Adak | Outer Coast, Adak |
|---|---|---|---|
| Male | 7 | 18 | 5 |
| Female, no pup | 10 | 9 | 14 |
| Female with pup | | | |
| small pup | 3 | 0 | 0 |
| medium pup | 11 | 10 | 3 |
| large pup | 5 | 4 | 16 |
| Sex unknown | 10 | 5 | 14 |
| **Total** | **46** | **46** | **45** |

### 4.5 Report Format
Reports will conform to specific guidelines set by the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/NRPM/index.cfm). Reports will include maps, graphs, figures and other visuals to facilitate comprehension of findings.

### 4.6 Methods for Trend Analyses
Refer to the SWAN Protocol Narrative for Marine Nearshore Ecosystem Monitoring (Dean and Bodkin 2011).

### 4.7 Data Archival Procedures
Refer to the SWAN Protocol Narrative for Marine Nearshore Ecosystem Monitoring (Dean and Bodkin 2011).

### 4.8 Reporting
Refer to the SWAN Protocol Narrative for Marine Nearshore Ecosystem Monitoring (Dean and Bodkin 2011).

# 5 Personnel Requirements and Training

## 5.1 Roles and Responsibilities

Each observer must be capable of locating and gaining visual access through binoculars and telescopes to foraging sea otters. Observers must be capable of quickly identifying and estimating the number and size of each prey item brought to the surface. Each observer must be familiar enough with the Questar to telescope to quickly locate a focal animal in the viewfinder and switch to 50 power as necessary to count and identify prey. Each prey item must be identified with certainty. If identification to species is not possible, the lowest possible taxon should be recorded (e.g. unidentified clam). To accurately and efficiently collect sea otter foraging data requires considerable skill and experience with the optics, sea otter behavior, and benthic marine invertebrate identification. Only observers with more than 500 prior sea otter foraging dives observations should hold primary foraging data observation responsibility.

Observer training should consist of assisting an experienced observer for at least 500 foraging dives from more than 50 foraging bouts. Based on simultaneous observations, an experienced observer may grant primary observer status to a trainee, based on the ability of the trainee to quickly and accurately identify, enumerate, and estimate the size of prey consumed by sea otters in the field. All personnel must be current with applicable federal government safety training.

# 6 Operational Requirements and Workloads

## 6.1 Operational Requirements

Operational requirements include transportation and access to shore, access and use of required optics(high resolution 10X binoculars and 50-80 X Questar telescopes) and electronics (e.g. GPS, stop watch), and access to taxonomic keys and guides to marine invertebrates common to the Gulf of Alaska.

## 6.2 Annual Workload and Field Schedule

Workload requires 10 person days per year for field data collection (1 person day per site x's 5 sites x's 2 regions), and 20 person days for lab and data analysis and reporting. Access to sites and observation locations are attained through small skiffs.

## 6.3 Facility and Equipment Needs

Equipment requirements to successfully conduct sea otter foraging observations include a small skiff w/ o/b motor (holds 3-4 people), sufficient staff to observe and assist in field procedures, marine safety equipment (hand held radios, flares), binoculars, stop watches and GPS units, home base computers (for data management, mapping, and data analysis), a printer and plotter, and hand fuel pumps with associated fueling equipment.

## 6.4 Start-up Costs and Budget Considerations

Startup costs include $6,000 for 2 Questar telescopess and tripods, $6,000 for 4 pair of binoculars (Leica, 10x 42 recommended), and $1,000 for miscellaneous field supplies such as stopwatches, clipboards, GPS, paper…). Annual operating budget estimated at approximately $40,000 for 4 regions, consisting of $30,000 for 20 d of vessel charter @$1,200/d, plus fuel and food (vessel charter costs included under the intertidal invertebrate and algal sampling).

# 7 Procedures for Revising the Protocol

All edits and amendments made to the protocol narrative and/or SOPs should be recorded in the revision history log table at the beginning of this document. Users of this protocol should promptly notify the project leader of the marine nearshore monitoring program of recommended edits or changes. The project leader will review and incorporate suggested changes as necessary, record these changes in the revision history log, and modify the date and version number on the title page of this document to reflect these changes.

It is anticipated that following at least five years of annual data collection it will be important to evaluate, in terms of power and sensitivity, the ability of the sampling design to detect change in the data derived from sea otter foraging observations.  Following such analyses it may be appropriate to consider revising sampling design or data collection protocols.

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# 9 Appendices

## Appendix A. Data sheet, data dictionary, and prey codes

**Data sheet**

| **Sea Otter Foraging Data SO-1** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Tags | | | |
| Date | Region | Site ID | Latitude | Longitude | | | | |
| Observer | Time Begin | Time End | Age | Sex | Pup | | | |
| | | | | | | | | |
| Day Bout ID | Dive ID | Dive Time | Surf Time | Success | Prey Item | Prey # | Prey Size | Give/ Take |
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## Data Dictionary

### Data Variables

| | |
|---|---|
| **OTTER ID** | Otter identification number, if tagged |
| **DATE** | Date of Survey. MM/DD/YY "05/09/98" |
| **REGION** | Characters indicating the Nearshore region, KATM, KEFJ, PWS, KOD, AP, KP<br>KATM = Katmai NP, KEFJ = Kenai Fjords NP, PWS = Prince William Sound,<br>KP = Kenai Peninsula, KOD = Kodiak, AP = Alaska Peninsula |
| **SITE ID** | Characters indicating closest intensive intertidal site |
| **LATITUDE** | Sea otters' position in decimal degrees, NAD83<br>(For example: 58.380567<br>. = no data |
| **LONGITUDE** | sea otters' position in decimal degrees<br>(NAD 83) "136.002345"<br>. = no data |
| **OBSERVER** | Name of the primary observer. first initial + up to 7 letters of last name<br>"JBODKIN" |
| **TIME BEGIN** | Start time of the observation. military time "18:45"<br>. = no data |
| **TIME END** | End time of observation. military time "20:30"<br>. = no data |
| **AGE** | Estimate age of the sea otter observed. P = pup A = adult<br>J = juvenile U = unknown |
| **SEX** | Gender of the sea otter observed. F = female U = unknown<br>M = male |
| **PUP** | Indicate if a pup was observed. Y = yes U = unknown<br>N = no and pup size S = small, M = medium, L = large |
| **DAY BOUT ID** | Sequential number assigned by observer during data collection. Each day all bouts will be uniquely renumbered sequentially. |
| **DIVE ID** | Sequentially numbered within bout |
| **DIVE TIME** | duration of foraging dive in seconds<br>. = no data |

**SURFACE TIME** duration of surface interval n seconds
. = no data

**SUCCESS** Success at recovering prey on that dive Y = yes U = unknown
N = no

**PREY NUMBER** whole number of prey items captured
. = no data

**PREY ITEM** Species of prey. Use prey codes on right side of page
. = no data
* go to next line if more than 1 item

**PREY SIZE** Size of prey caught. Use appropriate code from table below
. = no data
* go to next line if more than 1 size

| SIZE CLASS (mm) | Prey Size CODE | MID SIZE (mm) |
|---|---|---|
| 0 - 26 | 1A | 13 |
| 0 - 52 | 1B | 26 |
| 26 - 52 | 1C | 39 |
| 52 - 78 | 2A | 65 |
| 52 - 104 | 2B | 78 |
| 78 - 104 | 2C | 91 |
| 104 - 130 | 3A | 117 |
| 104 - 156 | 3B | 130 |
| 130 - 156 | 3C | 143 |
| > 156 | 4Z | 156+ |

**GIVE** proportion of prey given away, stolen or lost (typically the proportion given to a a pup by its' mother)

**TAKE** proportion of prey this otter took from another

**Prey Codes**

## Alaska Sea Otter Prey Species Codes

| Species Code | Genus Species | Common name |
|---|---|---|
| **CLAMS AND COCKLES** | | |
| CLN | *Clinocardium nuttallii* | Nuttall cockle |
| GAC | *Gari californica* | California sunset clam |
| ENN | *Entodesma navicula* | Ugly clam |
| HUK | *Humilaria kennerleyi* | |
| MAS | *Macoma* sp. | |
| MAP | *Mactromeris polynyma (Spisula)* | Arctic surf clam |
| MYA | *Mya arenaria* | |
| MYT | *Mya truncata* | |
| MYS | *Mya* sp. | |
| PRS | *Prototheca staminea* | Pacific littleneck clam |
| SAG | *Saxidomus giganteus* | Butter clam |
| SEG | *Serripes groenlandicus* | Greenland cockle |
| TRC | *Tresus capax* | Gaper clam |
| CLA | Unidentified clam | clam |
| **URCHINS** | | |
| STD | *Strongylocentrotus droebachiensis* | Green |
| STF | *Strongylocentrotus franciscanus* | Red |
| URC | Unidentified urchin | urchin |
| **CRABS** | | |
| CAM | *Cancer magister* | Dungeness |
| CAP | *Cancer productus* | Red rock |
| CHB | *Chionoecetes bairdi* | Tanner |
| ORG | *Oregonia gracilis* | Decorator |
| HYL | *Hyas lyratus* | Pacific lyre |
| PAC | *Paralithodes camtschatica* | Red king |
| PUG | *Pugettia* sp. | Kelp |
| TEC | *Telmessus cheiragonus* | Helmet |
| CRA | Unidentified crab | crab |
| **MUSSELS** | | |
| MOM | *Modiolus modiolus* | Horse |
| MTR | *Mytilus trossulus* | Blue |
| MUS | *Musculus sp* | mussel |

**SNAILS**

| | | |
|---|---|---|
| FUO | *Fusitriton oregonensis* | Hairy triton |
| NES | *Neptunea* sp. | |
| SNA | Unidentified snail | snail |

| Code | Genus Species | Common name |
|---|---|---|

**STARS**

| | | |
|---|---|---|
| GOC | *Gorgonocephalus caryi* | Basket |
| OPS | Ophiuroid sp. | Brittle |
| PYH | *Pycnopodia helianthoides* | Sunflower |
| SOS | *Solaster* sp. | Sun |
| STA | Unidentified sea star | star |

**OTHER**

| | | |
|---|---|---|
| APV | *Aptocyclus ventricosus* | Smooth lumpsucker |
| BIV | Unidentified bivalve | bivalve |
| BAS | *Balanus* sp. | barnacle |
| CHI | Unidentified chiton | chiton |
| CRS | *Cryptochiton stelleri* | Gumboot chiton |
| CUF | *Cucumaria fallax* | Sea cucumber |
| ECS | *Echiurus* sp. | Fat inkeeper |
| FIS | Unidentified fish | fish |
| HAA | *Halocynthia aurantium* | Sea peach |
| LIM | Unidentified limpet | limpet |
| OCD | *Octopus dofleini* | Octopus |
| PHA | *Phascolosoma agassizii* | Peanut worm |
| POM | *Pododesmus macroschisma* | Rock jingle |
| SCA | *Chalmys sp.* | scallop |
| SPO | Unidentified sponge | sponge |
| UNI | Unidentified prey | unidentified |
| WOR | Unidentified worm | worm |

## Appendix B Required PDFs

Bodkin et al.
2004.pdf

Dean et al. 2002

NPS 953/107697 Month Year

National Park Service
U.S. Department of the Interior

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